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PROCESS CONTROLS REQUIRED FOR LARGE SCALE PRODUCTION OF M796 IMPULSE CARTRIDGES

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This report describes the process controls utilized in producing high quality M796 Impulse Cartridges. In the initial study, emphasis was placed on material controls and manufacturing techniques to arrive at the desired item functioning characteristics. This led to the evolution of production of the impulse cartridge from a labor intensive hand line through development and fabrication of an automated machine for assembly.

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INTRODUCTION

The M796 impulse cartridge is currently being produced by the AMCOM Division of Action Manufacturing Company (AMC). This cartridge is used by both the United States Army and Air Force as the activating element in both M206 countermeasure aircraft flare and the M1 chaff cartridge, both of which are used with the M130 aircraft general purpose dispenser or the ALE-40 dispenser mounted on aircraft. Their purpose is to provide countermeasure protection for helicopter and fixed wing aircraft.

ITEM DESCRIPTION

Externally, the M796 impulse cartridge (fig. 1) is a flanged cylinder approximately 1/2 inch in diameter by 1/2 inch long. Electrical contact is made at the flanged end of the unit between the center pole and the case. The cartridge will not function with the application of voltage sufficient to maintain one ampere current through its one ohm bridge circuit for as long as 300 seconds. The cartridge is required to fire when no more than 4.25 ampere direct current is applied to the bridge circuit for a maximum of 15 ms.

The output required of the cartridge when fired in a closed bomb having a volume of 43.5 cm^3 is in terms of its pressure/time profile. The slope, rise time, peak pressure, and total functioning time of each functioning cartridge must fall within certain defined limits described in figure 2. A more detailed description of the cartridge and its requirements can be found on ARRADCOM drawing 9311660 and specification MIL-C-63108.

The cartridge consists essentially of a glass-to-metal seal electrode assembly which has a 0.0025 inch diameter 80/20 nickel/chromium alloy wire welded to the center electrode and to the outer metal ring (fig. 3). This is known as the header assembly. It is fitted into the bottom of the squib case and held there by an interference fit.

The first charge loaded into the cavity of this assembly is the initiation charge consisting of 20/80 boron/calcium chromate. One hundred milligrams of this pyrotechnic composition is consolidated against the bridgewire using a pressure of about 5500 pounds per square inch. The next charge, the booster charge, consists of 70 mg of another pyrotechnic mixture of 18/82 boron/potassium nitrate. This charge is consolidated over the initiation charge using about the same pressure of 5500 pounds per square inch. The third charge is 185 mg of unconsolidated HPC-1 propellant.

These charges are held in place through the assembly of a scored closing disc (fig. 4) and a retaining washer. These are held tightly against the squib case by crimping a portion of the case over the washer. Application of a sealant at all the joints on both ends and printing of the nomenclature and lot number on a flange completes the assembly of the cartridge. After a short period of drying, the cartridges are packed for shipment.

PRODUCTION

The Action Manufacturing Company has produced more than 2 million M796 impulse cartridges. Of the approximately 15 lots of cartridges represented, not one lot has been rejected. The obviously high quality of the items produced is attributed to the initial development of a high quality item with a complete and comprehensive technical data package, the automation of critical operations involved in its assembly, and the meticulous care taken in processing and handling of the reactive materials utilized.

ASSEMBLY

Initial production of the cartridge was accomplished through a labor intensive operation on a hand line utilizing a total of 11 people to produce 4000 cartridges per 8 hour shift. Current production, utilizing AMC designed automated equipment, requires only 5 people to produce 7500 cartridges per 8 hour shift.

One operation which lends itself to automation is the attachment of the bridgewire to the glass-to-metal seal plug. The equipment used for this type assembly, with minor modifications to accommodate different configurations and sizes of components to which the wire must be attached, is readily adaptable to a wide variety of electrically activated components. The device first used for this operation involved a wheel which merely positioned the wire on the terminals to which it was to be welded. The operator was required to index the machine manually as well as activate the welding operation. In addition, the operator also had to remove the wire "tails" and perform a resistance check operation.

Through the efforts of AMC's design engineers, a completely automated bridgewire welding machine, tooled for the finished welding of the bridgewire to the glass-to-metal sealed plug, was developed and put into operation. This machine (fig. 5), which also automatically checks the resistance of the finished bridge and rejects those out of tolerance, is capable of producing 7500 acceptable header assemblies per 8 hour shift.

The next major operation involved the automation of the assembly of all metallic and reactive materials to produce the complete cartridge. Again, AMC's design engineers designed, developed, fabricated, and put into operation this machine (fig. 6).

The squib cases, after being inspected and found to be acceptable, are placed in a vibratory feeder which positions the case in the proper orientation in the indexing table of the machine. The bridged header assemblies with their bridgewire assembly facing up, are fed by hand into the cavity of the indexing table over the open end of the squib case by an operator. At the conclusion of the indexing of the table at the first station a punch, through application of a force on the outer ring of the header assembly, seats this assembly into the squib case.

The machine table is indexed to its next position where a nominal charge of 100 mg of the initiation charge (as measured volumetrically by a Cargile loader) is dumped into the squib body assembly. The table is again indexed to the next station and here the loose initiation charge is consolidated. A sensor attached to the ram at the station is used to detect both the presence of and the height of the initiation charge. If the charge is too high or too low, further operations on this particular assembly are not conducted and the item is rejected at the last operating station. If the assembly of the charge is proper, another identical operation involving the assembly of the booster charge is conducted at the next two stations. After the second consolidation and before loading the HPC-1 charge, the resistance of the unit is checked automatically. The part is rejected if it is out of tolerance. The last loading station, where the HPC-1 propellant is introduced, differs from the first two loading stations in that an Iowa ball loader is used to volumetrically charge the assembly. This charge is not consolidated.

The operation conducted at the next station involves the blanking, scoring, and placing of the aluminum disc over the propellant charge. This is followed with the placement of the washer over the aluminum disc. Before the item is ejected from the machine, both 45° and final 90° crimping operations are conducted.

After the cartridge leaves the machine, it is subjected to another resistance check, all joints on both ends are sealed, and the nomenclature (identification and lot number) is printed on the flanged end. These operations are not yet fully automated.

PROCESSING

The first contract received by AMC, DAAK 10-80-C-0178, dated July 14, 1980 required delivery of 1,150,000 M796 impulse cartridges. During early stages of production, difficulties were encountered. These difficulties were one of two types. The first involved malfunctioning of the item wherein the complete washer/disc assembly separated from the main unit when the unit was activated (fig. 7). This type of failure was traceable to both the tooling used in the crimping operation and to the use of excessive epoxy sealant over the disc. The second type resulted in both functioning at the "no fire" energy level and nonfunctioning at the "all fire" energy level. This was attributed to items which had been subjectd to the aircraft vibration environment as described in specification MIL-C-63108. Items that failed were examined, x-rayed, and sectioned. It was determined that the basic cause of the failures was the breakup of the ignition charge (cake) from contact with the bridgewire. If no contact is made a dud results. If the initiation charge does not maintain proper contact along the total length of the bridgewire (loose powder), the probability of functioning at the "no fire" input energy level increases.

The first type of malfunction was corrected through proper design, use of two stage crimping tools, and better control on the quantity of sealant applied to the washer/disc assembly.

The second difficulty was not corrected as easily. A study program centering around the initiation charge to improve its cohesive characteristics was conducted. The following factors were investigated: consolidation pressure, dwell time of consolidation pressure, and average particle size of the composition.

The results of the tests conducted are summarized in table 1. It was concluded that functioning characteristics are affected by the consolidation pressure, dwell time of consolidation pressure, and the particle size of the initiation mix. Further work was conducted on the initiation charge which led to the production of an acceptable cartridge. The process controls that follow represent the optimum for achieving high rate production of M796 impulse cartridges which meet all functioning requirements.

The basic ingredients of the initiation mix, calcium chromate and boron, are procured to specifications MIL-C-48038 and MIL-B-51092, respectively. The calcium chromate is dried at a temperature of 871°C for a minimum 16 hours. At the end of this period it is passed once through a model 4-E Quaker City mill equipped with a F8-E/F No. 4B grinding head. The mill is operated at 89 rpm using a 1/3 hp motor. The particles are further reduced by passing twice through a Mikro-Samplmill (Serial No. 81 J51050 Mikropul, Division of the Slick Corporation) equipped with the fine screen number 3459-010. The average particle size (Fisher sub-sieve sizer) of the finished calcium chromate is in the order of 6 to 7 μ.

The boron is dried for a minimum of 12 hours at a temperature of 54°C. The average particle size has been determined to be approximately 0.8 μ, as received.

The mix is made by weighing out 600 g of the dried boron and placing it into a Type PC Lancaster counter current batch mixer. The muller is permitted to dry mix the boron for a period of 5 to 10 minutes. Then, 2400 g of the processed calcium chromate is weighed and added to the boron in the muller. The two materials are mixed dry for a period of 20 to 30 minutes. Approximately 750 mL of ethyl alcohol is added to the ingredients of the muller and then mixed an additional 5 minutes. Additional (about 250 mL) alcohol is added to form a wet-slurry. Mixing is continued for an additional 45 minutes. The mix is checked for a smooth consistency (more alcohol is added if necessary) and the side walls, rollers, and baffles are scraped down every 15 minutes. At the end of this period, air is passed over the mix while the muller is operating to hasten evaporation of the alcohol. This is continued (approximately 15 minutes) until the mix approaches a semi-dry, crumbly texture. When this state is reached, the mix is removed from the muller. One half the batch (at a time) is passed through a Stokes Model 43A oscillatory granulator equipped with a #30 sieve. The mix is then stored in an oven at 54°C for a minimum of 3 days. Before it is issued to the line for use, it is tumbled for a period of 15 minutes.

The boron/potassium nitrate mix used as the booster is processed in a similar manner. Both the ingredients are dried a minimum of 16 hours at 54°C. Like the calcium chromate, the potassium nitrate is passed once through the grinder and twice through the micropulverizer. The average particle size of the potassium nitrate, as determined by the Fisher sub-sieve sizer, is approximately 12 to 15 μ. The boron and potassium nitrate are weighed out, 360 g and 1640 g, respectively, placed in the Lancaster muller, boron first, and followed 5 to 10 minutes

later by the potassium nitrate which is passed through a #20 sieve into the muller. These ingredients are dry mixed for a period of 20 to 30 minutes. The remaining process is identical to that used in preparing the boron/calcium chromate mix described above. The mix is also tumbled for 15 minutes prior to issuing it for use.

The HPC-1 propellant is procured from Hercules, Inc. and is used as received. A certificate of analysis is included with each lot of propellant. It is stored in an unheated magazine until used.

CONCLUSIONS

It is concluded that the M796 impulse cartridge can be and is being produced in very large quantities to meet all specification requirements consistently by following the various procedures and controls outlined above. Functioning characteristics of the cartridges representing those produced using the automatic assembly equipment and material processing controls described above are contained on the test data sheet (table 2). As can be seen, all values fall well within the requirements specified in MIL-C-63108.

Table 1. Effects of particle size of initiation composition, consolidation pressure, and dwell time of consolidation pressure on functioning characteristics of the M796 impulse cartridge

Consolidation pressure (psi)	Peak pressure (psi)		Functioning time (msec)		Rise time (msec)		Slope (psi/ms)	
	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ
Dwell time 4.5 seconds								
Average particle size ignition composition 5μ								
5500	670.9	8.95	36.6	2.27	12.3	0.35	57.5	2.78
6500	662.0	4.51	37.4	2.40	13.4	0.73	50.5	3.21
7500	662.4	8.24	36.4	1.69	13.4	0.75	50.1	3.43
Average particle size ignition composition 3μ								
5500	669.9	6.01	36.7	1.24	12.4	0.93	56.5	5.51
6500	656.8	4.25	36.1	0.76	13.0	1.70	52.1	7.43
7500	666.4	5.65	34.8	1.39	12.2	1.15	56.9	6.76
Dwell time 2.5 seconds								
Average particle size ignition composition 5μ								
5500	669.0	4.65	38.0	3.07	13.9	1.88	49.7	8.39
Average particle size ignition composition 3μ								
5500	667.1	8.20	36.5	4.65	12.5	1.15	55.6	6.25

Table 2. Closed bomb test for M796 impulse cartridge

Lot #AMN82M003-001 Date: February 1, 1983

No. unit	No fire test	Secure crimp ACC/REJ	Peak pressure[a]	Total function time[b]	Rise time[c]	Slope[d]
1	ACC	ACC	598.5	37.50	15.05	479.0/11.85
2	ACC	ACC	631.0	35.45	12.30	503.0/ 9.40
3	ACC	ACC	604.0	37.40	13.65	483.0/10.60
4	ACC	ACC	586.5	34.70	13.65	469.5/10.60
5	ACC	ACC	613.5	37.05	13.75	390.0/ 9.00
6	ACC	ACC	609.5	38.00	14.50	488.5/11.40
7	ACC	ACC	622.0	40.45	13.30	495.0/10.35
8	ACC	ACC	596.5	36.25	11.75	480.0/ 8.95
9	ACC	ACC	577.5	41.15	16.65	464.5/13.10
10	ACC	ACC	627.0	36.30	12.65	504.5/ 9.85
11	ACC	ACC	609.0	33.90	12.15	497.0/ 9.45
12	ACC	ACC	627.0	35.50	13.10	501.0/10.05
13	ACC	ACC	623.5	38.95	13.50	500/0/10.55
14	ACC	ACC	594.5	39.10	13.20	478.0/10.15
15	ACC	ACC	613.5	39.10	13.60	490.5/10.30
16	ACC	ACC	625.0	37.30	14.35	500.5/11.35
17	ACC	ACC	623.0	35.85	12.70	499.5/ 9.75
18	ACC	ACC	641.0	40.30	11.95	514.0/ 8.90
19	ACC	ACC	618.5	36.55	13.45	498.0/10.25
20	ACC	ACC	628.0	37.10	14.35	501.0/11.55
21	ACC	ACC	595.0	35.65	12.05	474.0/ 9.00
22	ACC	ACC	614.0	40.25	13.50	492.5/10.40
23	ACC	ACC	614.0	36.30	13.30	492.0/10.35
24	ACC	ACC	609.0	39.95	14.40	492.0/10.35
25	ACC	ACC	623.5	36.25	12.45	499.5/ 9.60
26	ACC	ACC	605.0	37.00	12.40	485.0/ 9.50
27	ACC	ACC	627.5	34.95	12.80	502.5/ 9.80
28	ACC	ACC	631.5	37.95	14.45	505.5/11.25
29	ACC	ACC	612.5	42.25	12.65	491.0/ 9.45

[a] 450 psi min; 750 psi max

[b] 50 ms max

[c] 25 ms max

[d] 150 psi/ms max

Table 2 (continued).

Lot #AMN82M003-001 Date: February 1, 1983

No. unit	No fire test	Secure crimp ACC/REJ	Peak pressure[a]	Total function time[b]	Rise time[c]	Slope[d]
30	ACC	ACC	602.0	38.20	16.05	482.0/13.15
31	ACC	ACC	608.5	37.30	12.40	487.0/ 9.35
32	ACC	ACC	607.5	36.85	13.10	488.0/10.30
33	ACC	ACC	626.0	34.55	11.55	500/0/ 8.85
34	ACC	ACC	659.0	37.10	10.85	529.5/ 8.05
35	ACC	ACC	636.0	36.00	13.30	508.0/10.22
36	ACC	ACC	655.0	33.80	13.05	495.5/ 9.45
37	ACC	ACC	615.0	40.50	13.80	492.0/10.95
38	ACC	ACC	634.5	37.10	12.95	506.0/10.00
39	ACC	ACC	589.5	38.05	12.70	474.0/ 9.30
40	ACC	ACC	624.0	38.05	11.65	499.5/ 8.90
41	ACC	ACC	614.0	36.40	12.25	492.0/ 9.15
42	ACC	ACC	625.5	37.35	12.55	501.0/ 9.60
43	ACC	ACC	623.0	37.05	13.40	499.0/10.25
44	ACC	ACC	636.5	36.95	12.65	510.5/ 9.50
45	ACC	ACC	619.5	37.90	13.90	497.5/10.80
46	ACC	ACC	641.0	39.20	10.20	515.5/ 7.60
47	ACC	ACC	597.0	37.00	13.50	480.0/10.65
48	ACC	ACC	656.0	36.70	12.70	527.0/10.15
49	ACC	ACC	610.5	36.40	13.60	489.0/10.25
50	ACC	ACC	627.5	36.70	13.85	505.5/11.15
		$\bar{x}$	618.2	37.4	13.2	49.4
		δ	17.4	1.8	1.2	6.0

[a] 450 psi min; 750 psi max

[b] 50 ms max

[c] 25 ms max

[d] 150 psi/ms max

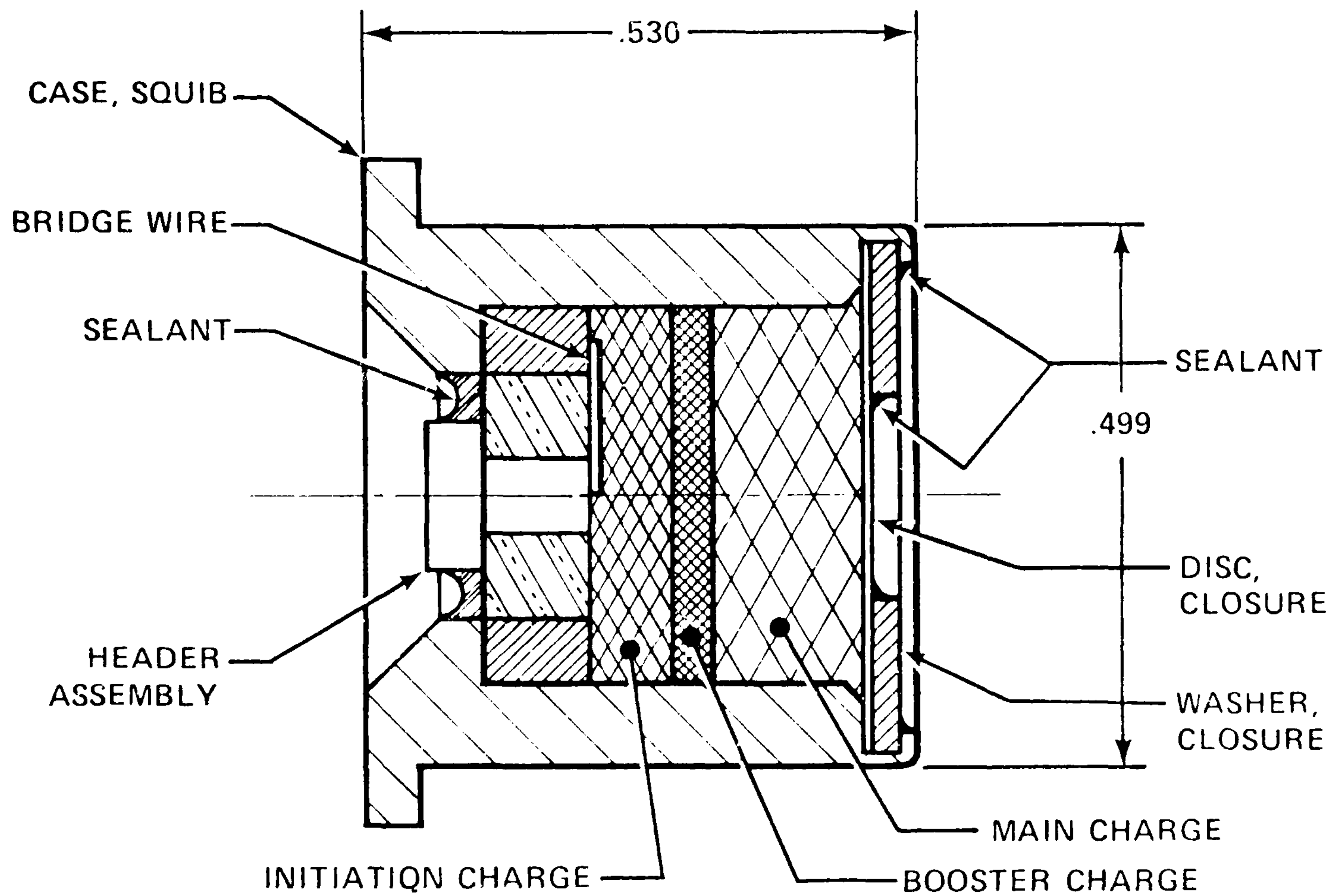

Figure 1. M796 impulse cartridge

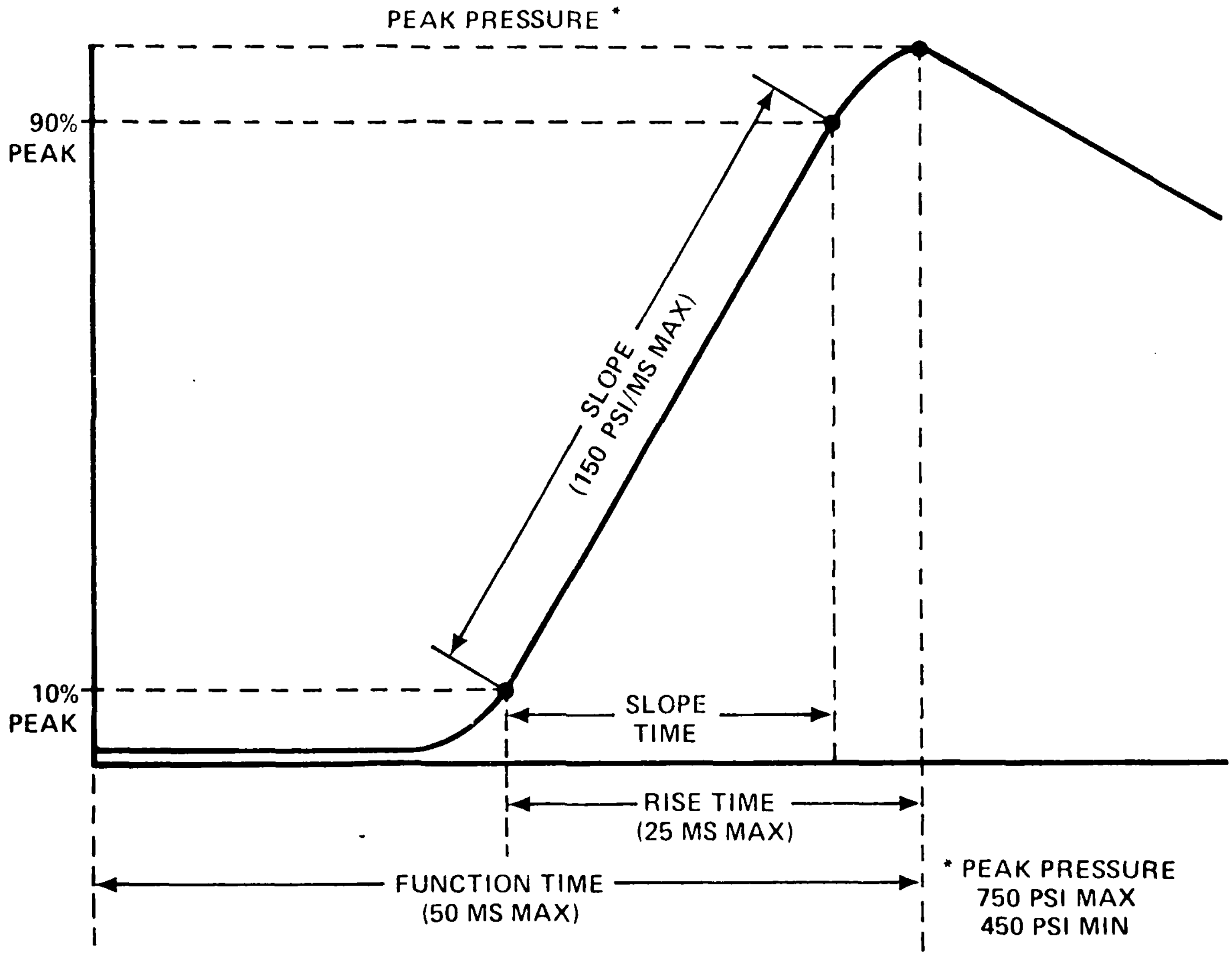

Figure 2. Functional characteristics of M796 impulse cartridge

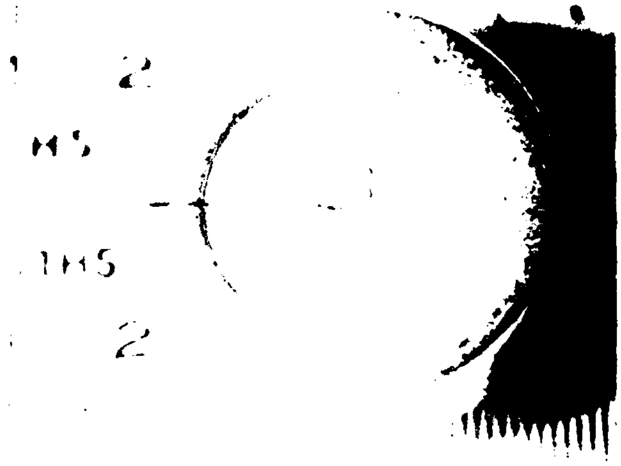

Figure 3. Header assembly

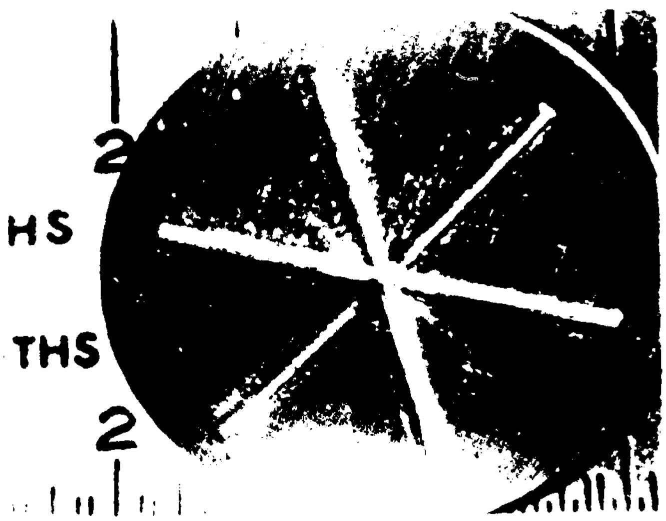

Figure 4. Closure disc

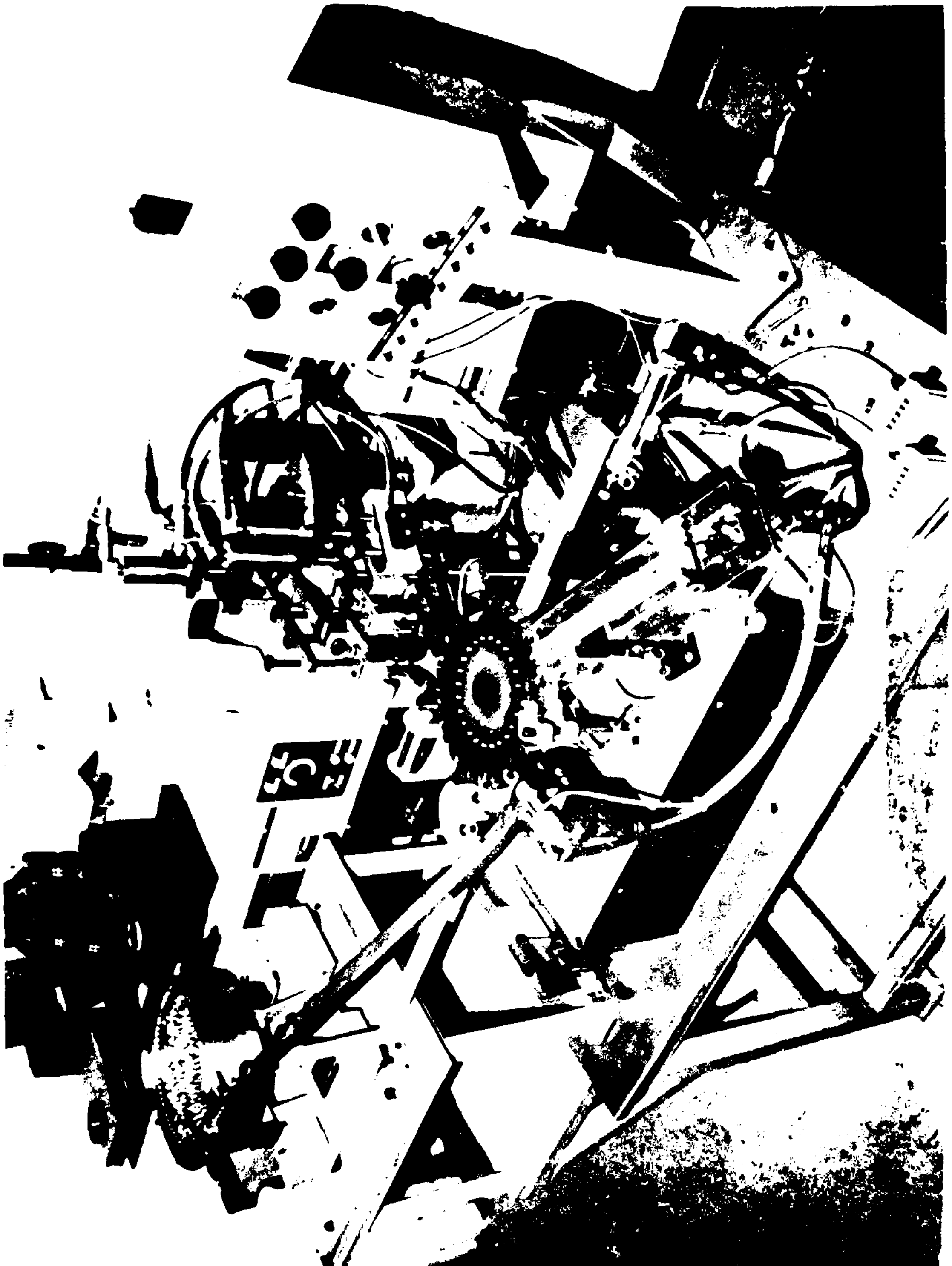

Figure 5. Bridge wire welding machine

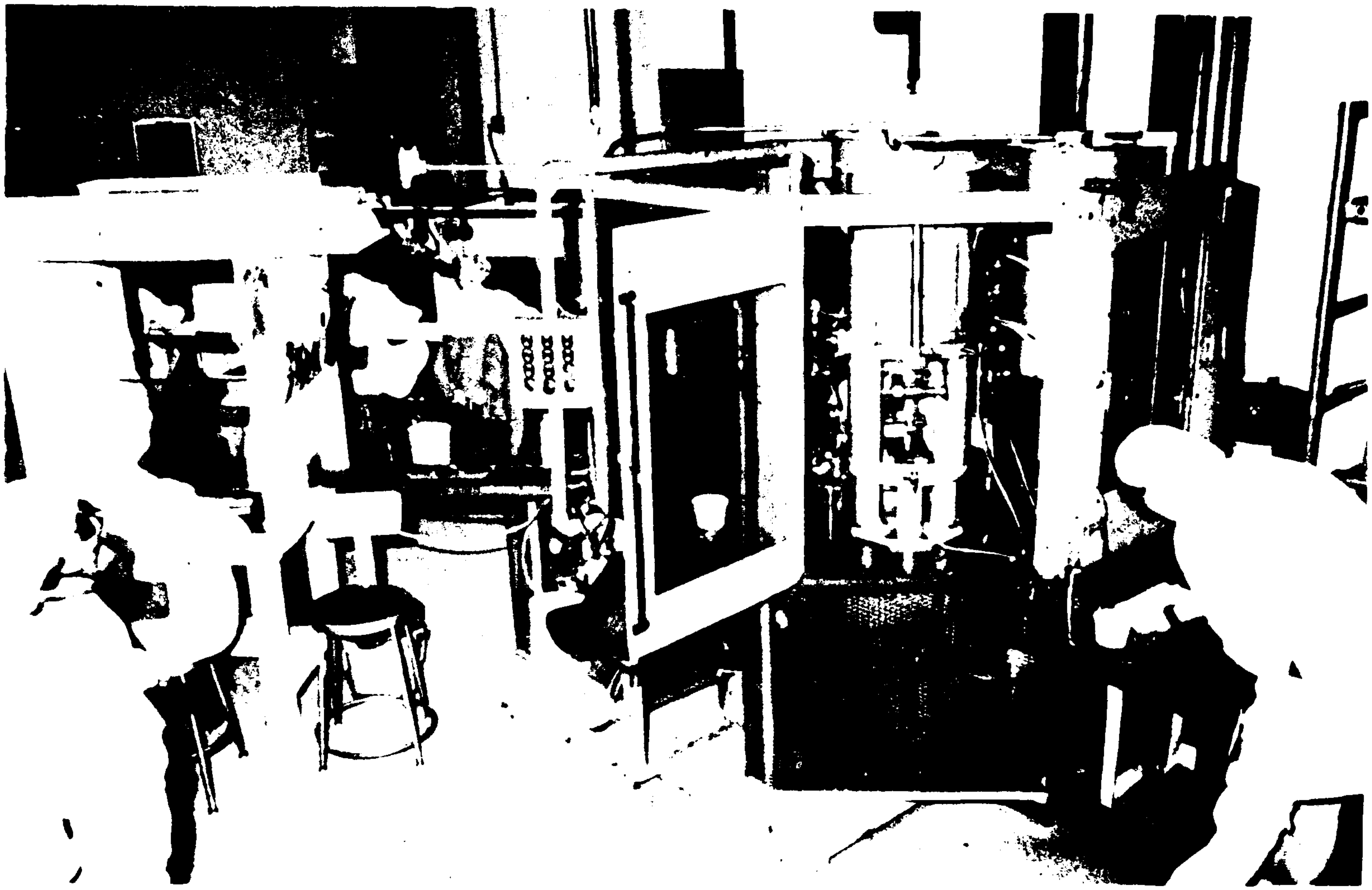

Figure 6. Multi-station loader

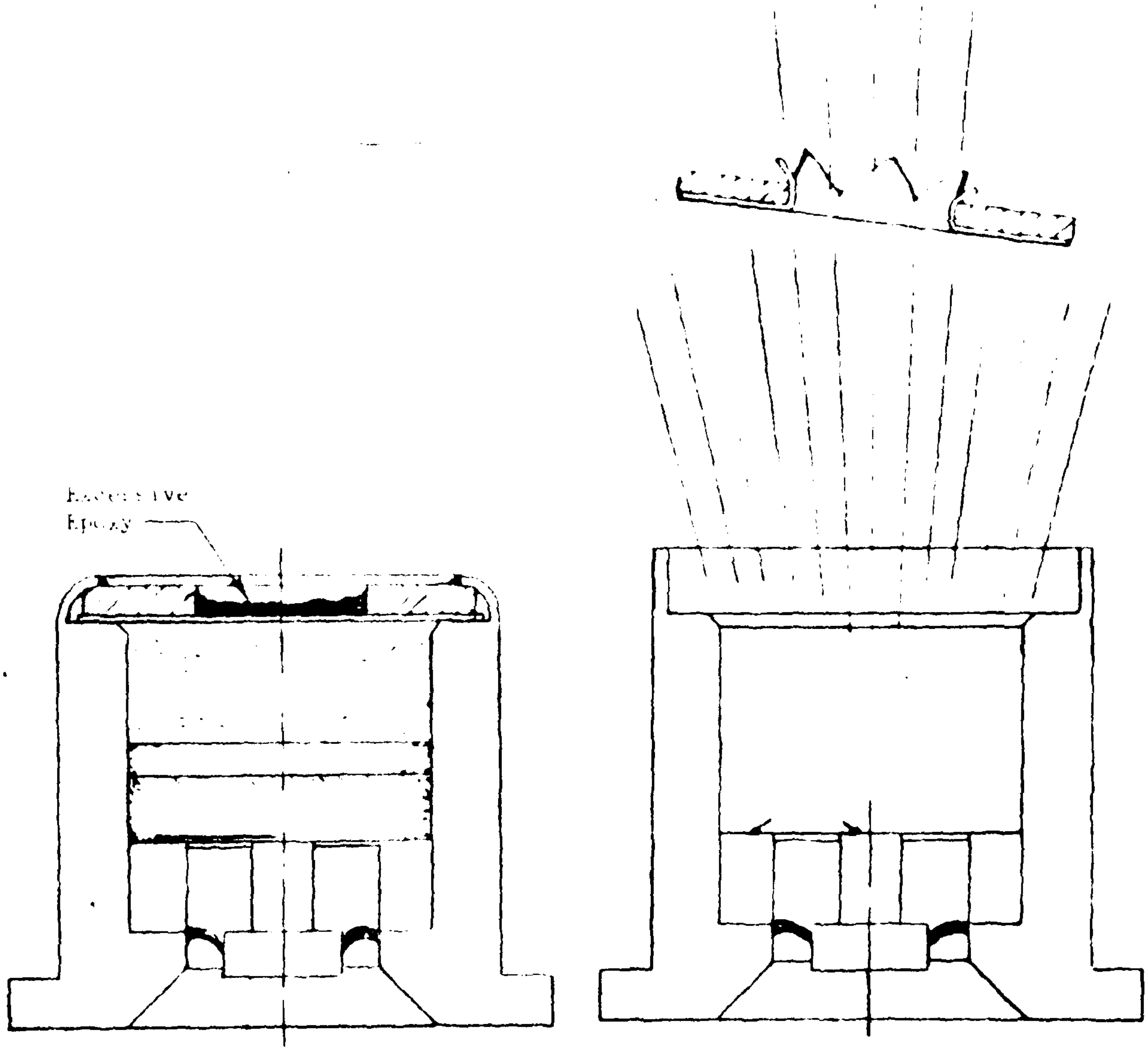

Figure 7. Washer/disc failure

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